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Photographic Interpretation Handbook, United States Forces: Section 09 Height and Depth Finding from Parallax

Robert L. Bolin Depositor
University of Nebraska-Lincoln, rbolin2@unl.edu

SECTION 9
HEIGHT PARALLAX

9.01 — 9.99

USE OF INSTRUMENTS IN DETERMINING HEIGHT
OF OBJECTS FROM PARALLAX MEASURENTS

Determining the height of objects in vertical aerial photographs by measurement of differential parallax involves the use of such instruments as a stereocomparagraph, height or contour finder, interpretometer, or a parallax bar. In measuring directly with the scale or parallax bar, care must be taken to measure only the component of displacement in the direction of flight. This is done for both prints and the two figures subtracted if displacement is in the same direction, or added if in opposite directions.

The contour finder accomplishes the measurement by means of two small dots on the bottom surfaces of glass plates carried by the stereoscope. These dots are practically in the plane of the picture, one remains in a fixed position beneath the left eye piece of the stereoscope while the other may be moved back and forth in the line of flight beneath the right eye piece. Measurement is accomplished essentially by placing the left dot on one of the two points between which the difference in elevation is desired. The other dot is moved to exactly the same point on the right photograph or to such a position that it appears to fuze with the left dot and the fuzed image appears to be at the same level as the point. A reading of the micrometer dial of the stereocomparagraph, or of the position of the sliding wedge of the interpretometer is then made, which records the position of the right dot. The stereoscope assembly is then moved, remaining parallel to the line of flight, so that the left dot is on the second point. Again, the right dot is moved so that it occupies the same point on the right photograph or visually coincides with the left and the fuzed dot appears to be at the level of the second point. A second reading is taken of the position of the right dot and the difference between the two readings is a measure of the differential parallax, the unit of measure depending, of course, on the calibration of the instrument. If calibrated in millimeters or decimal parts of inches, the reading should be converted to decimal parts of feet for use in the formula so that the calculated height of the object will be in feet.

The procedure requires much practice in fuzing the dots at just the proper elevation and a good eye in appreciating relative depth. The surfaces or objects must have photographic tone and detail in order that a comparison of elevation may be made. White surfaces, for example, do not give an impression of position or depth. Moreover, actual manipulation of the dial, in the case of the stereocomparagraph, for relatively accurate readings requires that the right dot approach the left for fusion in the same direction at each point so as to eliminate play in the dial mechanism.

GRAPHIC SOLUTION OF FORMULA FOR DETERMINING HEIGHTS OF OBJECTS FROM PARALLAX MEASUREMENT

The accompanying graph for determining heights of objects on stereo pairs of vertical photographs from a measurement of parallax solves the formula:

$$ho = \frac{H \times P}{W}$$

Where: ho = height of object
H = height of aircraft
P = parallax measurement
W = distance between centers of photographs

The above formula is a simplification of the form:

$$ho = \frac{H \times P}{W + P}$$

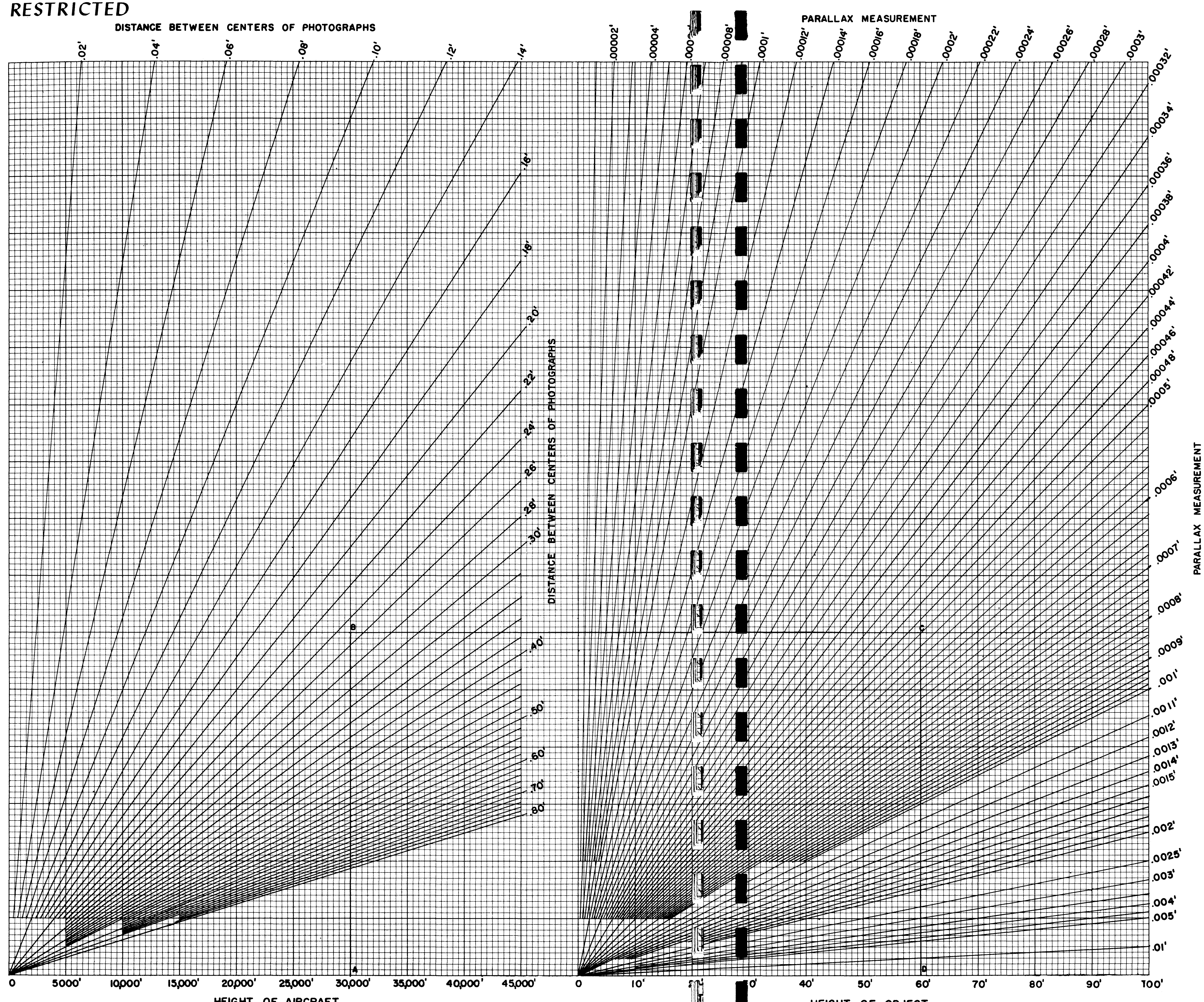
where the value of P is small with respect to W, a condition true in all but very large scale photos of objects or terrain of marked relief.

The graph is designed for use where all measurements are in feet, however, it will work equally well with other units of measure provided all measurements in a particular problem are in the same units.

EXAMPLE:- On aerial photographs taken from an altitude of 30,000 feet the parallax due to the height of a chimney was found by measurement to be .0005 feet. The center of one photograph was plotted on the other and the distance between the two centers was found to be .25 feet. The height of chimney may be determined as follows:

From a position "A", representing 30,000 feet on the scale for aircraft heights along the left half of the lower margin of the graph, follow a vertical line to the position "B", an interpolated point between oblique lines .24 feet and .26 feet for distance between centers of photos. From position "B" follow horizontal line to position "C" on oblique line .0005 feet representing the parallax measurement. From position "C" follow vertical line to position "D" at bottom of graph where height of object is found to be 60 feet.

Note:- The decimal point in any of the factors involved in the graph may be moved, provided it is moved properly in the answer. For example, if it is desired to move the decimal point one position on the scale for height of aircraft, or for the indicated parallax, it will be moved one position in the same direction in the answer. If, however, the decimal point in the indicated value of the distance between centers of photographs is moved one position, the decimal point in the value of the height of the object will be moved one position in the opposite direction.


DISTANCE BETWEEN CENTERS OF PHOTOGRAPHS
.02' .04' .06' .08' .10' .12' .14' .16' .18' .20' .22' .24' .26' .28' .30' .40' .50' .60' .70' .80'
DISTANCE BETWEEN CENTERS OF PHOTOGRAPHS
HEIGHT OF AIRCRAFT
0 5000' 10,000' 15,000' 20,000' 25,000' 30,000' 35,000' 40,000' 45,000'
PARALLAX MEASUREMENT
.00002' .00004' .00008' .0001' .00012' .00014' .00016' .00018' .0002' .00022' .00024' .00026' .00028' .0003'
.00032' .00034' .00036' .00038' .0004' .00042' .00044' .00046' .00048' .0005' .0006' .0007' .0008' .0009' .001' .0011' .0012' .0013' .0014' .0015' .002' .0025' .003' .004' .005' .01'
PARALLAX MEASUREMENT
HEIGHT OF OBJECT
0 10' 40' 50' 60' 70' 80' 90' 100'
A B C D

DEPTH MEASUREMENT BY PARALLAX
USING SONNE STRIP PHOTOGRAPHS

The Sonne camera photographs a continuous strip of terrain by allowing the negative to move continuously over a fixed slit at the focal plane of the camera. The speed with which the film moves is adjusted to the height and speed of the aircraft. The Sonne camera has been modified to permit stereo coverage by using two lenses and partitioning the camera cone so that two strips are photographed side by side on the negative. Parallax is obtained by causing the lens assembly to be rotated in a horizontal plane so that one lens is in advance of the other. As a consequence, a different portion of terrain image is directed toward the slit on each side of the partition at any one time, and an appreciable time interval elapses between exposures of the same detail on each side of the negative. The angle which the lens assembly is rotated from a neutral position - that in which neither lens is in advance of the other - determines the amount of parallax which can be measured for any particular height or depth. A rotation which permits about 5° between the rays directed to the slit, where the focal length of the lenses is 100 mm., is considered most satisfactory.

Sonne strip photography is especially adapted to low altitude flying and permits much more accurate determination of height and depth, provided the speed of the film is correctly maintained so as to eliminate distortion in line of flight. At 200' altitude the plane travels about 21 feet from the position where a particular point is recorded by the forward lens to where the same detail is recorded by the aft lens. The relatively short interval of time between exposures of the same point at high plane speeds is of particular value in depth of water determinations, where the bottom of the water can be discerned, in that the top surface of the water is photographed stereoscopically in a nearly static condition, producing a stereoscopically visible base or datum level from which to make depth measurements.

Determining height of objects or depth of water by parallax measurement on parallel strip photographs is essentially similar to the procdeure involved in using ordinary stereo pairs. Prints from equivalent parts of the two strips may be cut and arranged under the height finder in the same way as an ordinary stereo pair, orienting each print so that measurement will be made in the direction of flight. Parallax may also be measured by a stereoscopic viewer having a parallax attachment which is so designed as to permit examination and measurement of the parallel strips without the necessity of cutting and arranging photos under an ordinary height finder.

In determining depth of water, the "floating dot" of the height finder is adjusted at the same elevation as a point on the water surface on the upper part of the stereo pair. The dot is then moved to the lower part of the picture. Using the first point as a center, one picture is rotated until the second surface point appears at the same elevation as the dot.

If all surface points on the stereo pair are not at the same elevation, allowing for differences due to waves, such a condition may have resulted from change of plane direction during photography, or to forward and back tip of the plane in line of flight. Tilt across the line of flight does not affect vertical measurements. The water surface will appear to change elevation only along the line of flight if the photos are carefully rotated as described above. To avoid the effects of distortion, measurements should be made of depths occurring along a line across the direction of flight. Photos should be reoriented for each such line across the pictures.

For best results the following conditions should exist:.

1. The lens assembly should be rotated for about 5° between rays.
2. Plane altitude should be constant and less than 300'
3. Speed of film should be carefully coordinated with heighth and speed of plane. Improper coordination will result in a distorted parallax measurement.
4. The sun should be at such an angle that the bottom is well lighted and that occasional ripples show on the surface.
5. Photographic plane runs should be straight lines.
6. The bottom should not be obscured by surface disturbance, silt, etc.

The condition of the tide at the time of photography should be taken into consideration so that depths may be determined at future times.

The formulae which may be used to determine heights of objects and depths of water are as follows:

$$\text{height} = \frac{H \cdot P}{2 \cdot f \cdot \tan \frac{1}{2}a}$$

$$\text{depth} = \frac{H \cdot P}{2 \cdot f \cdot \sin \frac{1}{2}a}\sqrt{n^2 - \sin^2 \tfrac{1}{2}a}$$

The depth formula, however, may be simplified to

$$\text{depth} = \frac{1.34\, H \cdot P}{2 \cdot f \cdot \sin \frac{1}{2}a} \quad \text{for practical purposes.}$$

Where: H = height of aircraft
P = parallax measurement
f = focal length of camera lens
a = angle between light rays directed to camera slit, read directly on calibrated scale from amount of rotation of lens assembly
n = 1.34 = index of refraction of water
All linear measurements in same units.

With a focal length for the camera lens of 100 mm. or .328 feet, and an angle of 5° the formulae may be simplified to the following:

Where P is measured in millimeters and H in feet:

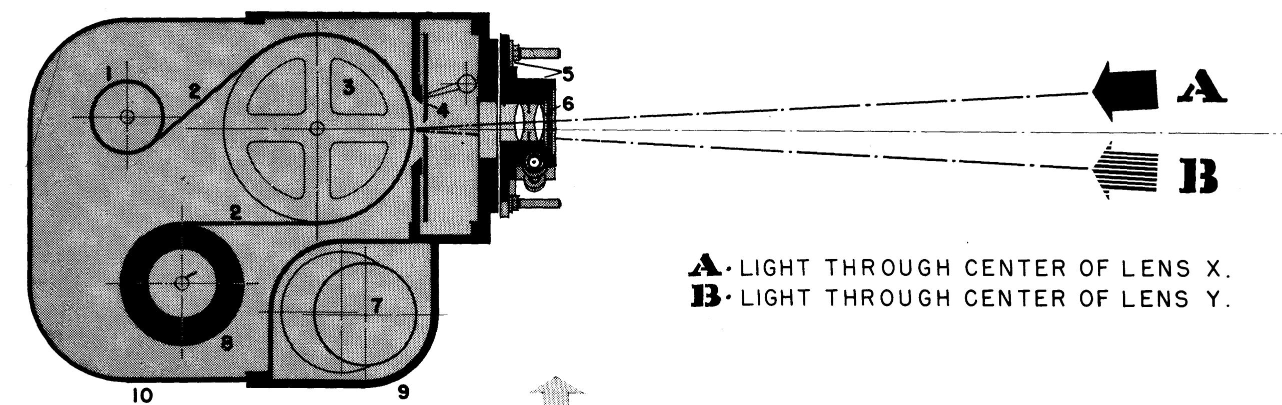
$$\text{height} = \frac{H \cdot P}{(2)(100)(.0437)} = \frac{H \cdot P}{8.73} \text{ feet}$$

$$\text{depth} = \frac{1.34\, H \cdot P}{(2)(100)(.0436)} = \frac{H \cdot P}{6.51} \text{ feet}$$

Where P is measured in decimal parts of feet and H in feet:

$$\text{height} = \frac{(12)(25.4)\ H \cdot P}{8.73} = 34.9\ H \cdot P \text{ feet}$$

$$\text{depth} = \frac{(12)(25.4)\ H \cdot P}{6.51} = 46.8\ H \cdot P \text{ feet}$$

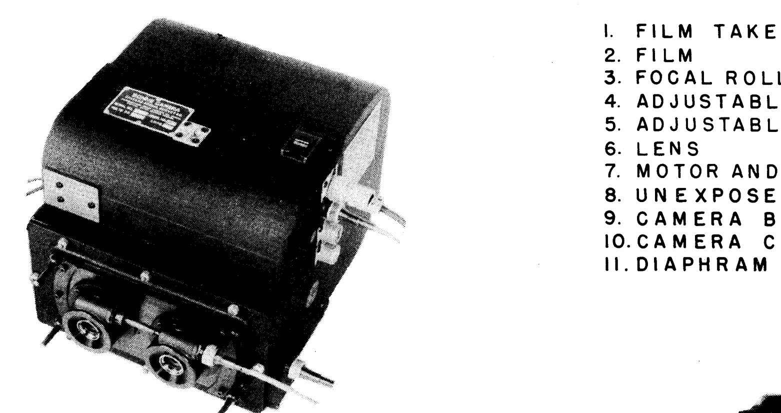


A· LIGHT THROUGH CENTER OF LENS X.
B· LIGHT THROUGH CENTER OF LENS Y.

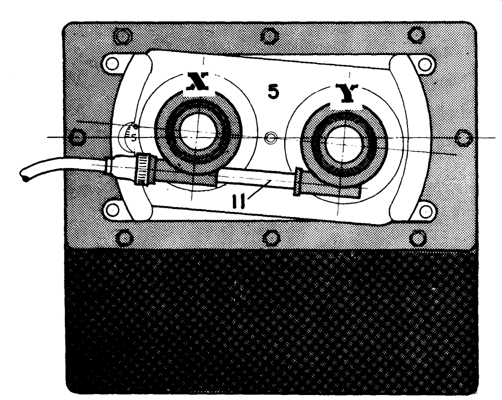
S E C T I O N

SONNE CAMERA

1. FILM TAKE UP SPOOL
2. FILM
3. FOCAL ROLLER
4. ADJUSTABLE APERTURE
5. ADJUSTABLE LENS TURRET
6. LENS
7. MOTOR AND VARIABLE SPEED TRANSMISSION
8. UNEXPOSED FILM SPOOL
9. CAMERA BODY
10. CAMERA COVER
11. DIAPHRAM CONTROL



VIEW SHOWING LENS TURRET IN ROTATED POSITION



S T E R E O – V I E W E R
SHOWN IN OPEN POSITION